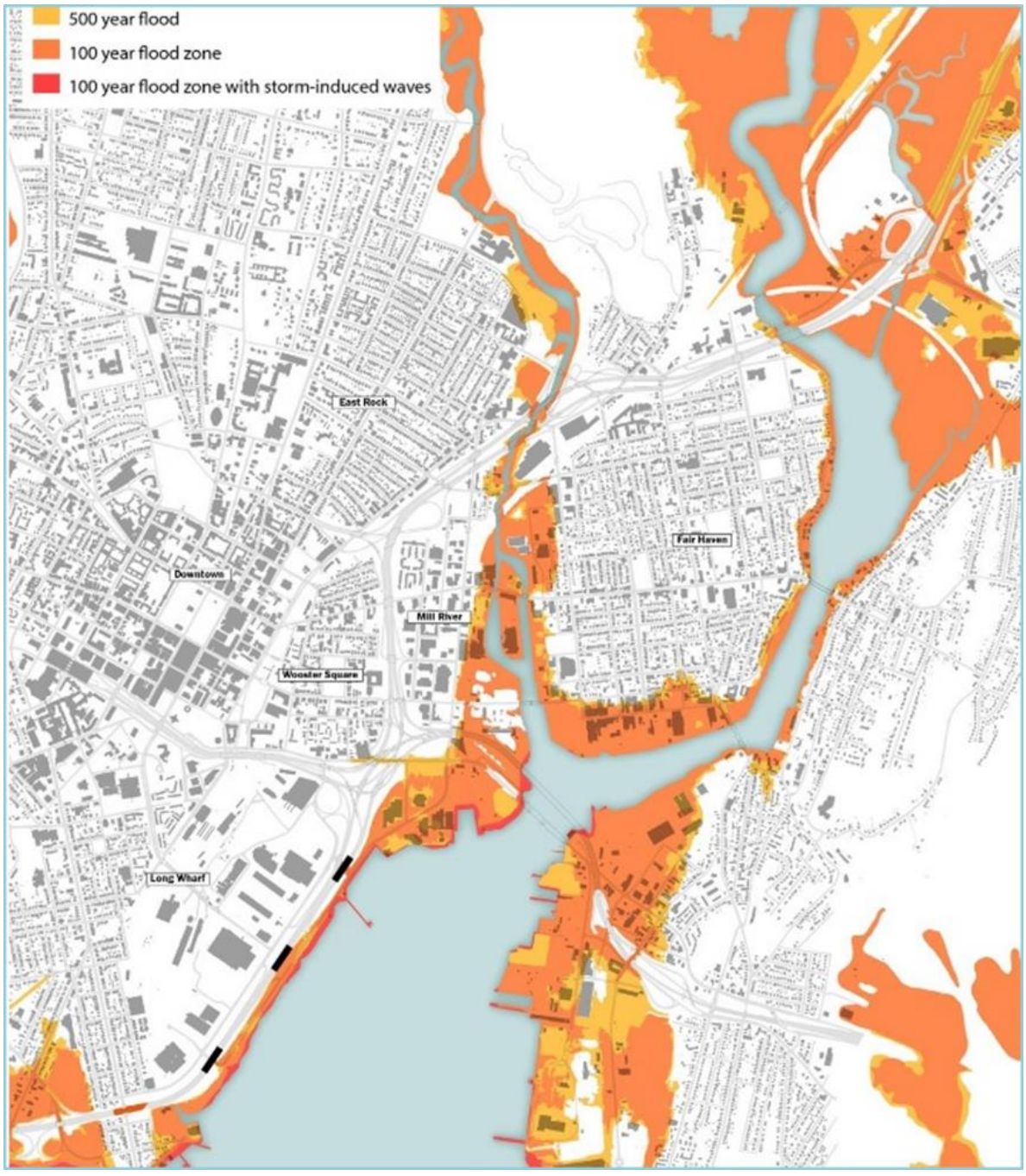
City of New Haven Commercial Industrial Toolbox Final Report



Prepared for: Connecticut Institute for Climate and Resilience Adaptation

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July 31, 2017
Mayor Toni Harp

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1. Executive Summary

The New Haven Commercial-Industrial Toolbox (CIT) serves as a guide to promote resilient construction and renovation techniques applicable to commercial and industrial properties within flood-prone areas. The CIT is a means to implement some of the goals of the New Haven Hazard Mitigation Plan (HMP). The HMP frames the City's priorities and recommendations in the context of a changing climate and related increasingly intense storm events, and focuses on strategies that can serve to raise public awareness about flood-related risks, reduce or prevent damages from future flood and storm surge events, and restore economic losses as quickly as possible. Strategies aim to protect life and property, and minimize temporary loss of business operations due to flooding. The CIT furthers the mission of the PPI by educating commercial and industrial stakeholders on how to prepare, adapt and quickly recover from major flooding events.

The award of this CIRCA[1] grant allowed New Haven to receive $20,000, which was matched at $10,000 by the City of New Haven, to assist in the creation of the New Haven Commercial Industrial Toolbox ("CIT"). Specifically, this grant enabled the City to do the following:

- Evaluate the needs of commercial industrial businesses in coastal hazardous areas
- Develop best practices in renovation, construction, and federal insurance to build the resiliency of infrastructure in commercial industry
- Distribute critical information and resources to local commercial industrial stakeholders
- Further serve the mission of the Program for Public Information
- Avoid loss of property and life in future instances of severe storms and flooding

This project added significantly to the City's commercial industrial sector's resilience in the face of rising sea levels and increasingly severe storm and rainwater flooding. By improving the infrastructure of the City's commercial and industrial properties, the City and local businesses would likely save money and avoid lawsuits in the aftermath of floods.

The CIT grant application was made by the City's Office of Economic Development Administration and the planning process was led by the City Plan Department in association with CDM Smith Consultants. Although content provided in the New Haven CIT will be specific to and for the City's commercial businesses, the template of CIT will nevertheless be transferable to many Connecticut municipalities—other Connecticut locations will be able to apply the framework of CIT to their unique and individual circumstances and challenges to enhance the resilience of their human-built infrastructure.

[1] The Connecticut Institute for Resilience and Climate Adaptation ("CIRCA") Municipal Resilience Grant Program is a partnership between the University of Connecticut and the Connecticut Department of Energy and Environmental Protection.

2. Project Background and Context

As a coastal town, New Haven experiences frequent flooding due to heavy rainfall and increasingly severe hurricanes and winter storms. Weather-related flooding is compounded by a high rate of sea level rise of 2.5mm per year (the global mean trend is 0.5mm per year). Flooding events negatively impact and can cause closures in New Haven's commercial downtown area. For instance, New Haven's most recent and severe storms—Hurricanes Irene and Sandy—both cost the City hundreds of thousands of dollars in damages and loss revenue, exposing weaknesses in the City's preparedness to severe weather and flooding.

The City of New Haven is in full compliance with the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP), and, as of April 2016, entered FEMA's Community Rating System (CRS). The NFIP is a voluntary program through which property owners in participating communities can purchase Federal flood insurance as a protection against flood losses. FEMA rewards CRS communities that go above and beyond the minimum NFIP floodplain management requirements by discounting flood insurance premium rates. The CRS ascribes points to activities that fall into four objectives: Public Information, Mapping and Regulations, Flood Damage Reduction, and Warning and Response. Under the Public Information objective, the City created a Program for Public Information (PPI).

In 2014, New Haven assembled the Program for Public Information ("PPI")—a committee of individuals from inside and outside local government—to assess the needs of New Haven with respect to flooding. In addition, the Committee was charged with developing strategies for conveying this information through a comprehensive outreach plan. After several months, the PPI Committee ultimately devised a plan, suggesting various areas that the City should target for outreach. New Haven proposed to implement one of the Committee's recommendations: the New Haven Commercial Industrial Toolbox ("CIT").

The aim of the CIT was to enhance the resilience of commercial infrastructure to flooding and high sea-level rise in order to help New Haven adapt to a changing climate and to enhance the resilience of our infrastructure. This project worked in coordination with the City's Hazard Mitigation Plan, Mill River Planning Study and the National Flood Insurance Program's Community Rating System. As such, this project is focused on implementation.

3. Project Description

The CIT included various communication measures to educate commercial property owners about flooding risk. The study includes case studies of relevant and similar projects in the United States and public outreach targeting local commercial and industrial stakeholders.

Project Goals

- Evaluate the needs of commercial industrial businesses in coastal hazardous areas

- Develop best practices in renovation, construction, and federal insurance to build the resiliency of infrastructure in commercial industry
- Distribute critical information and resources to local commercial industrial stakeholders
- Further serve the mission of the Program for Public Information (PPI)
- Avoid loss of property and life in future instances of severe storms and flooding

Planning Method

First, stakeholders from coastal areas of the City were identified to develop potential solutions and invited to stakeholder meetings. Consultants made presentations on the risk of sea level rise, which included resources available to the stakeholders to prepare, adapt, and recover from such events. Two stakeholder meetings were held in the months of March and April, 2017. These meetings also served as listening sessions where city staff and consultants could understand stakeholders' issues and priorities.

The first stakeholder meeting was held on March 13, 2017. Attendees included:

Contact	**Company**
Jed Backus	Backus Real Estate/NHMR CID
Dave Sousa	CDM Smith Consultant
Daniel O'Neill	City of New Haven (CNH), Deputy Building Inspector,
Susmitha Attota	CNH, Assistant Director of City Planning
Steve Fontana	CNH, Deputy Economic Development Director
Carlos Eyzaquirre	CNH, Economic Development Officer
Mary Ellen McMahon	Hummel Bros, Inc.
Jeff Zeitlin	IKEA
Tom Adamo	Regional Water Association

The second stakeholder meeting was held on April 25, 2017. Attendees included:

Contact	**Company**
Jed Backus	Backus Real Estate/NHMR CID
Dave Sousa	CDM Smith Consultant
Susmitha Attota	CNH, Assistant Director of City Planning
Karyn Gilvarg	CNH, Director of City Planning
Carlos Eyzaquirre	CNH, Economic Development Officer
Lao Triffin	Fair Haven Furniture
Josh Buenstein	Long Wharf Theatre
Bill Neale	Radiall
Tom Adamo	Regional Water Association
Fereshteh Bekhrad	Riverfront Development LLC
Kerry Triffin	Triffin Building LLC

The following questions were discussed at these meetings:

- Have business operations been interrupted due to flood damage?
- If so, what was the extent of the damage/interruption?

- Were you previously aware of the National Flood Insurance Program (NFIP) and the Community Rating System (CRS)?
- Are you aware of other resources?
- Do you think that the City or State should do more to assist property owners with resources? What specifically?
- Have you employed/constructed any mitigation strategies on your property, if so, what specifically?
- If you have mitigated your property to any degree, would you be willing to share your work or lessons learned with other property owners? And would you be willing to be videotaped as a case study?
- Would you be willing to share any pre- and post-flood pictures of your property?
- How can the CIT be most helpful to you and your needs?
- What would be the best strategy to get the word out on the CIT?
- Who else should we include as a stakeholder?

The CIT was also discussed at various neighborhood stakeholder CMT meetings:

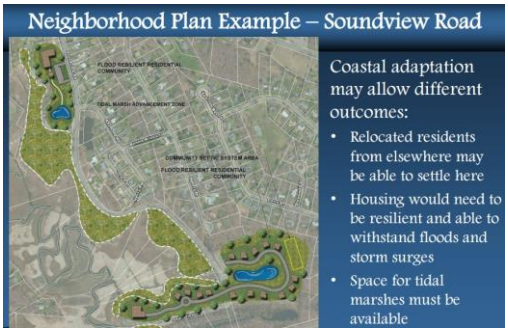
Presentation Audience	**Date Given**	**Attendees**
Quinnipiac East Neighborhood	6/6/2017	25+
East Shore Neighborhood	6/13/2017	25+
Downtown Neighborhood	6/23/2017	25+

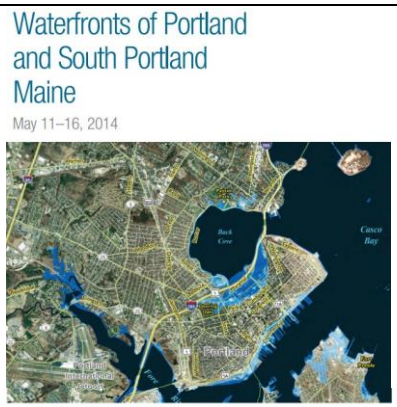
The City Plan Department handpicked specific commercial flood-prone sites in order to understand what is already being done to mitigate coastal flooding. Consultants and City staff visited these sites to understand flooding issues better. They also interviewed business owners to find out what they were already doing to mitigate flooding.

A set of case studies from US communities with similar weather-related vulnerabilities was evaluated. Communities were selected on their risk of coastal inundation or riverine flooding, blend of residential and commercial areas, and regional economic center status. These communities are in the process of evaluating potential flooding and sea level rise impacts and developing resiliency strategies through efforts comparable to the New Haven CIT. The case studies range in specificity – from providing a general framework for climate change vulnerability and risk assessments to site-specific proposed mitigation measures for industrial buildings in neighborhoods that are faced with coastal inundation. The findings are found in the table below:

Relevant case studies of similar initiatives

LOCATION	TITLE AND WEBLINK	
Bridgeport, CT	Resilient Bridgeport: Projects and Proposals, Atlas (July 2016) **http://resilientbridgeport.com** **http://resilientbridgeport.com/pdf/Atlas.pdf**	
	The Resilient Bridgeport pilot project is funded by the U.S. Department of Housing and Urban Development (HUD), and focuses on protecting housing in the city's South End from chronic and acute flooding. The resilience strategy is organized into three separate area plans (Black Rock Harbor/Cedar Creek, South End – West, and South End – East) for communities that are threatened by rising sea levels, storm surge, and heavy rainfall. In its entirety, the resilience strategy puts forth a vision for Bridgeport as a whole, especially since coastal areas are vital to the local and regional economy. Residents are connected to the waterfront and to coastal habitats. Roadways, public spaces, water and power networks, and buildings are designed and built for "living with water," and a future in which heavy rainfall and periodic inundation recur more frequently. The Atlas defines the design conditions for the City to use during the analysis, long-term plan, and implementation of strategies. As part of these efforts, a pilot project area was selected and potential flood mitigation measures were developed.	

Guilford, CT	Town of Guilford Community Coastal Resilience Plan (May 2014) Town of Guilford Community Coastal Resilience Plan Report of Options to Increase Coastal Resilience (February 2013) **http://www.ci.guilford.ct.us/pdf/community-coastal-resilience-plan.pdf** **http://www.ci.guilford.ct.us/pdf/community-coastal-resilience-planReport%20of%20Options.pdf**	
	The Town of Guilford Community Coastal Resilience Plan was developed in association with The Nature Conservancy and Yale University Urban Ecology and Design Laboratory and builds upon existing planning efforts, including a *Report of Options to Increase Coastal Resilience*. The plan presents two examples for building resilience at the neighborhood scale, one of which is in a commercial/industrial area. The report develops and evaluates "Zones of Shared Risk," considers potential trade-offs between measures, and recommends a phased approach to help the town address the most urgent and well-understood vulnerabilities and risks in the short term while addressing remaining vulnerabilities and risks later. Public participation and input is an important component to deriving adaptation strategies.	

Portland, ME	Waterfronts of Portland and South Portland Maine: Regional Strategies for Creating Resilient Waterfronts (May 2014) **http://www.portlandmaine.gov/DocumentCenter/View/7035**	
	This report was developed by the Urban Land Institute Advisory Services Panel. This report's recommendations fall broadly into three categories: (a) economic diversity, (b) planning and development, and (c) leadership and governance for Portland and South Portland, ME. Maritime life and industry are a critical part of the region's identity, tourism industry, and port infrastructure. The region has begun to consider risks of climate change in planning for its waterfront and has taken steps to protect new development against future risks. This report details a risk assessment, that focused on planning and development strategies for the built environment, and provides recommendations to the city and region for governance and implementation of those strategies. A conceptual approach of how the city can protect one of its major waterfront areas is presented in the report.	 

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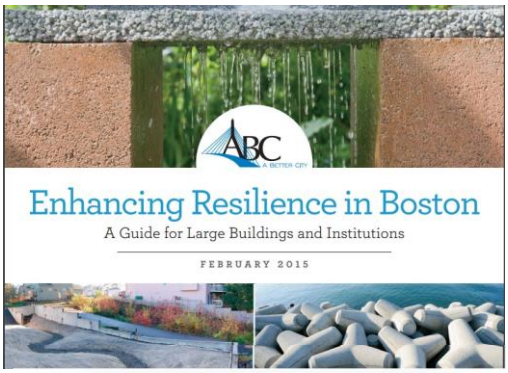
<tr><td>Boston, MA</td><td colspan="2">Enhancing Resilience in Boston: A Guide for Large Buildings and Institutions (February 2015)
http://www.abettercity.org/docs/resiliency%20report%20web%20FINAL.pdf
Building Resilience in Boston: Best Practices for Climate Change Adaptation and Resilience for Existing Buildings (July 2013)
http://www.greenribboncommission.org/archive/files/Building_Resilience_in_Boston-(July-2013).pdf
Building Resilience Toolkit
http://challengeforsustainability.org/resiliency-toolkit/</td></tr>
<tr><td></td><td>The Boston Green Ribbon Commission’s Climate Preparedness Working Group released the Enhancing Resilience Report that presents and evaluates resilience options for private sector buildings. The guide and online toolkit provide building owners with information on 32 available resilience actions and technologies. The toolkit discusses definitions, estimated unit costs, applications, benefits, drawbacks, regulatory considerations, project examples, sample suppliers, and other references. It also provides a preliminary assessment of potential regulatory constraints within the city and state for resilience actions, and considers initial ideas for district-level resilience strategies for the Boston area. The related Building Resilience Report prepared by the same group includes a review of national and international research, publications, planning documents, and related materials to establish the state-of-knowledge and identify “best practices” related to the improvement of existing buildings to better withstand climate change impacts. The mitigation strategies discussed in both reports are included in the Building Resilience Toolkit, an online database of measures geared towards existing commercial buildings.</td><td> 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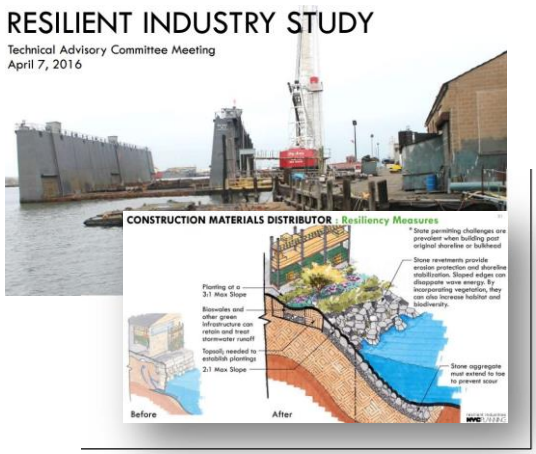
New York City, NY	New York City Planning: Resilient Industry (Ongoing) https://www1.nyc.gov/site/planning/plans/resilient-industry/resilient-industry.page https://www1.nyc.gov/assets/planning/download/pdf/plans-studies/resilient-industry/tacmeeting-presentation-061515.pdf	
	The Resilient Industry study is a planning initiative to assess the vulnerability to flooding in industrial areas of New York City and propose strategies that individual businesses and the City can pursue to make industrial areas and surrounding communities more resilient in the face of flooding. Hurricane Sandy highlighted this vulnerability, resulting in substantial losses to some businesses, harmful environmental impacts, and damage to surrounding communities. As part of the final report from this analysis, prototypical site analyses are being performed for various waterfront industries and best practices for both physical and operational strategies that businesses can pursue to withstand flooding are being evaluated.	

Finally, the City developed a Commercial Industrial Toolkit brochure (Appendix A), a document that details how to build in New Haven's floodplains. It will be distributed to local realtors, businesses, and industries and will also be handed out during Site Plan Review meetings to commercial or industrial applicants who propose to build in the City's floodplains. Finally, the brochure and other resources will be uploaded to the City website, which will likely gain more traction as the whole City moves to a new, more user-friendly site in the next two weeks.

4. Project Alignment with CIRCA's Mission

CIT advances CIRCA's mission by increasing the capacity of local commercial industrial stakeholders to understand and minimize the environmental risks that their businesses face. In order to accomplish the project's ultimate goal of enhancing the resilience and sustainability of commercial industry in New Haven, CIT equips commercial industrial entities with the necessary tools to assess environmental risks and respond to those risks with strategic rebuilding, renovation, and restructuring. This project accomplished this by researching environmental risks in New Haven's coastal commercial areas and providing best practices for resilient renovation of existing structures.

This project is also relevant to CIRCA's focus on vulnerable communities. In general, commercial industry constitutes an integral sector of local communities and economies throughout Connecticut, yet commercial industry is also an entity that is particularly susceptible to coastal

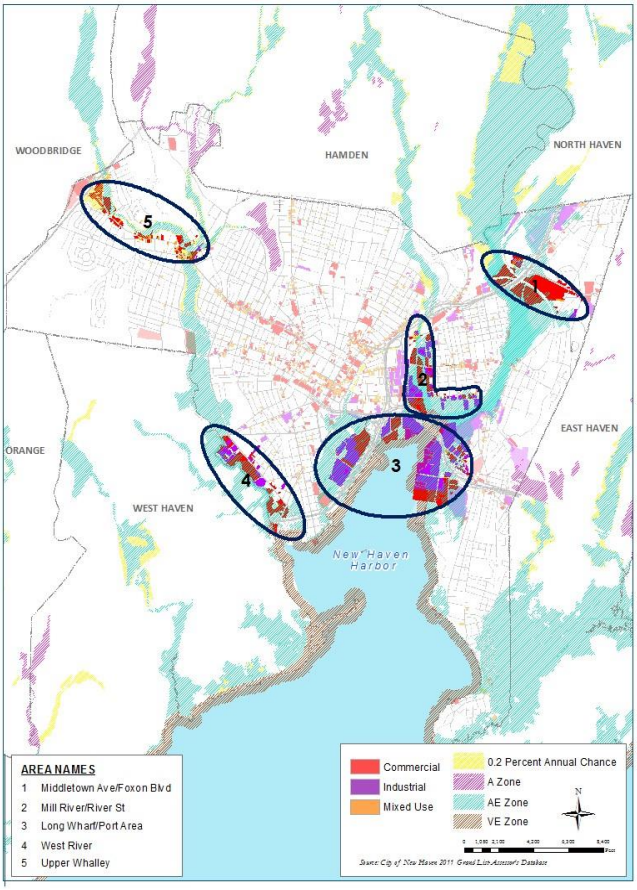
environmental insecurities particularly among transportation and technology infrastructure. While many resiliency studies were undertaken in Connecticut for the shoreline, quite a few have been conducted for already developed areas. Thus, this CIT brochure and tech memo would benefit in the advancement of climate resiliency for the already built environment in Connecticut.

5. Project Outcomes

Overview of Vulnerable Commercial and Industrial Properties

There are approximately 2,875 commercial buildings within New Haven, equating to nearly $6 billion of building value.[2] Commercial and industrial uses account for more than 29 percent of existing land use within the city[3] and are predominantly found within five areas that are particularly vulnerable to flooding, as shown in **Figure 1** below.

Figure 1. Commercial & Industrial Concentrations in Special Flood Hazard Areas



Area 1: Middletown Avenue/Foxon Boulevard

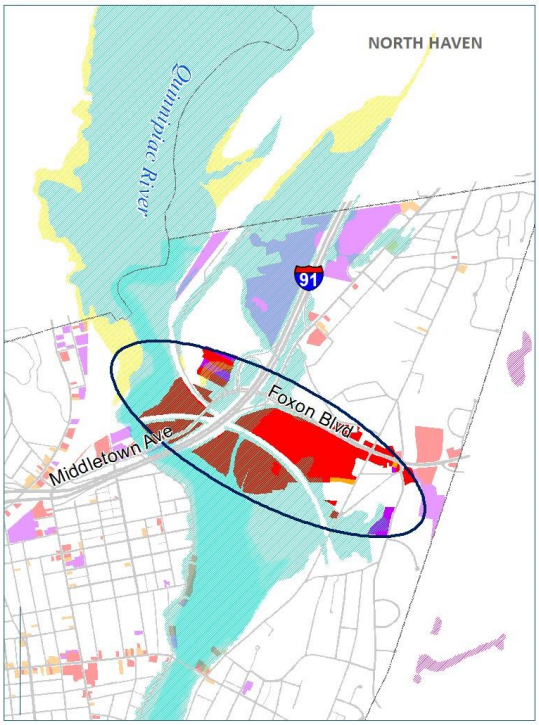
The area surrounding where Middletown Avenue crosses over the Quinnipiac River and becomes Foxon Boulevard, shown in the figures below, is within the 100-year floodplain (A Zone and AE

[2] City of New Haven, *Draft Natural Hazard Mitigation Plan Update,* October 2016

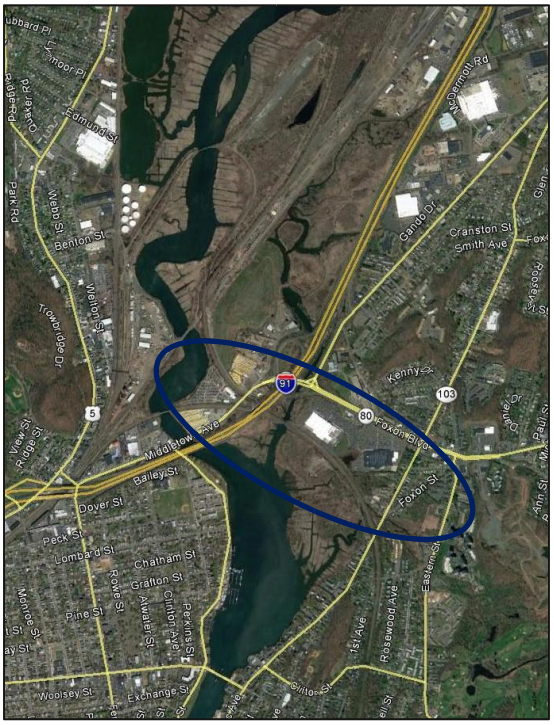
[3] Ibid.

Zone) and 500-year floodplain (0.2 percent annual chance) associated with the Quinnipiac River. The area is prone to flooding due to its low-lying and flat topography and the size of the Quinnipiac River watershed that lies up-river.

Figures 2a and 2b. Area 1



Source: City of New Haven

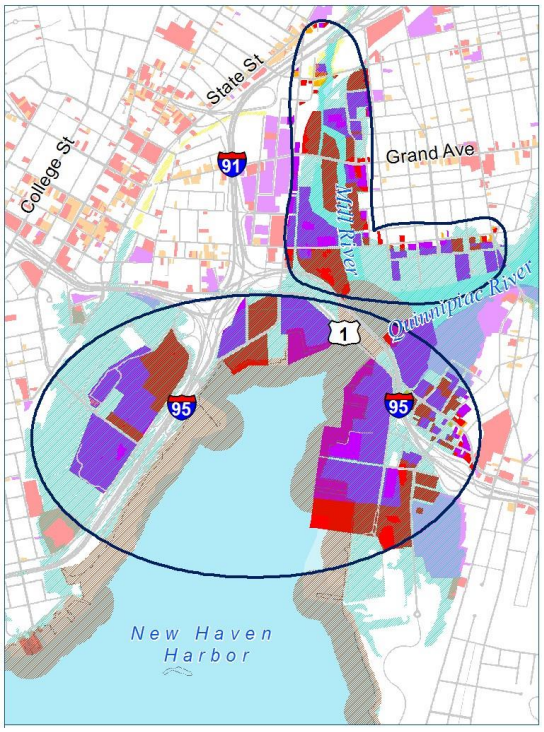


Source: Google Earth Pro

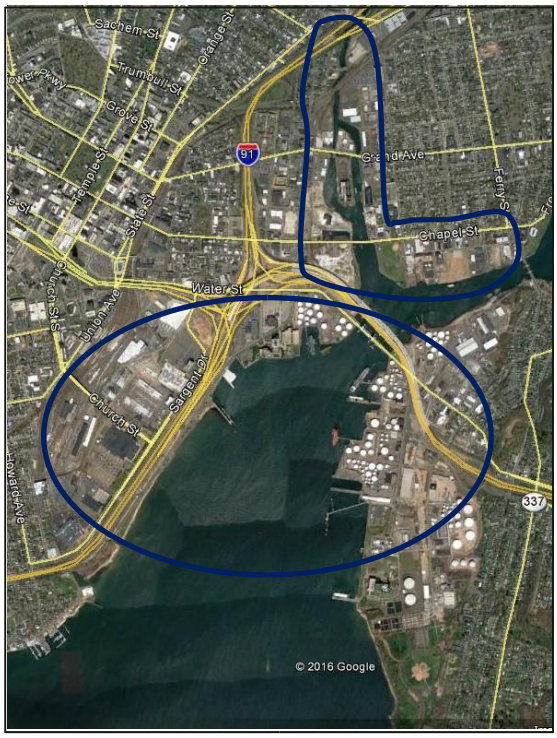
Area 2: Mill River/River Street and Area 3: Long Wharf/Port Area

Mill River and Long Wharf are commercial/industrial districts prone to coastal flooding. As shown in **Figures 3a** and **3b**, both areas are within the 100-year floodplain (A Zone, AE Zone and VE Zone), as well as partly within a velocity hazard area (VE Zone). The Mill River district lies at the confluence of the Mill and Quinnipiac Rivers. Both the Mill River and Long Wharf districts lie within coastal hazard areas associated with Long Island Sound.

Figures 3a and 3b. Areas 2 and 3.



Source: City of New Haven

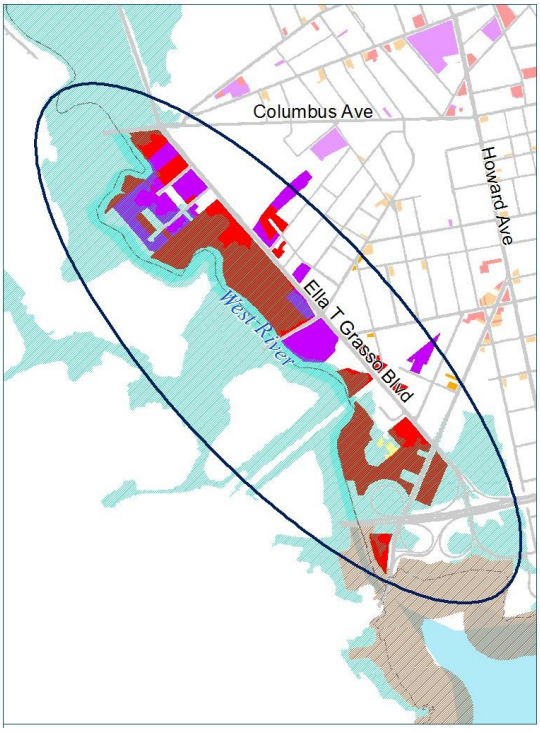


Source: Google Earth Pro

Area 4: West River

Industrial and commercial uses are concentrated along Ella T. Grasso Boulevard in the Hill neighborhood of the city. Much of the area west of the boulevard and south of Kimberly Avenue lies within the 100-year floodplain (shown below) associated with the West River and is prone to inland flooding events and is also vulnerable to coastal flooding. The southern portion of the West River district, the area closer to New Haven Harbor, is located within a velocity hazard area and is prone to coastal flooding and storm surges. In recent years, the area's susceptibility to flooding has been reduced due to the installation of self-regulating tide gates in 2012, as well as recent tidal marsh and channel restoration projects.

Figures 4a and 4b. Area 4.



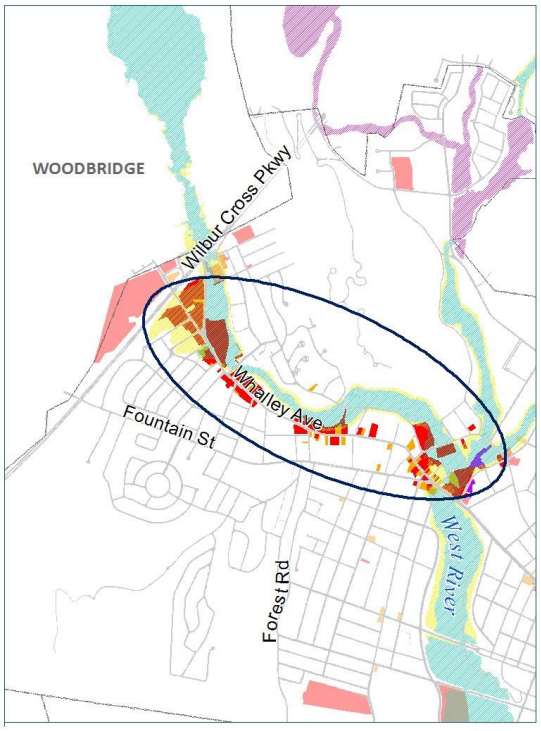
Source: City of New Haven

Source: Google Earth Pro

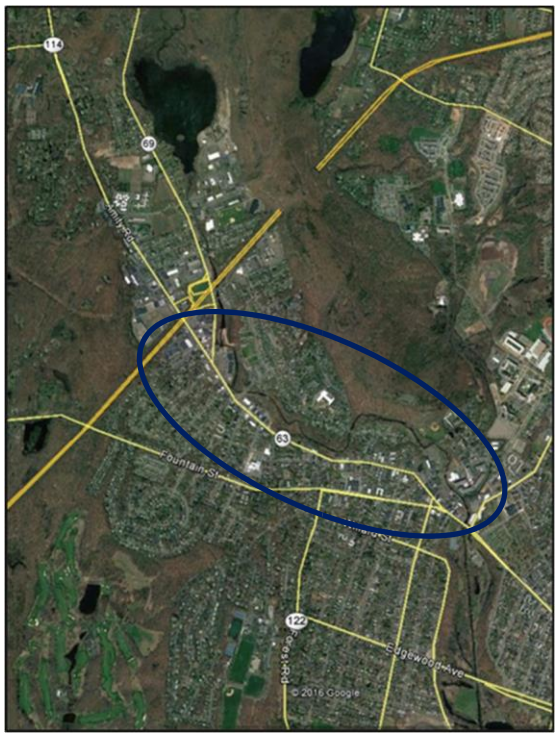
Area 5: Upper Whalley

The Upper Whalley area in northwestern New Haven is situated along the West River. The area is characterized by a mix of commercial and residential uses and is located within the 500-year and 100-year floodplains (shown in the figures below).

Figures 5a and 5b. Area 5.



Source: City of New Haven



Source: Google Earth Pro

As these exhibits illustrate, a large percentage of commercial and industrial properties within New Haven are concentrated in areas prone to riverine and coastal flooding. The total potential economic loss from a 100-year riverine flood is projected to be nearly $32.88 million for commercial and industrial businesses ($32.60 million for building-related losses and $0.28 million for business interruption losses).[4] The total potential economic loss from a 100-year coastal flood event is estimated to be substantially more: $176.61 million ($175.22 million of commercial and industrial building-related losses, and $1.39 million of business interruption losses).[5] The NFIP offers commercial policyholders coverage for up to $500,000 each for building property and contents of the business. Property outside of a building, such as walkways, septic systems and

[4] Total includes municipal losses as well. City of New Haven, *Draft Natural Hazard Mitigation Plan Update,* October 2016

[5] City of New Haven, *Draft Natural Hazard Mitigation Plan Update,* October 2016

fences are not covered by the NFIP, neither are business interruption losses.[6] Therefore, incorporating flood damage mitigation strategies into commercial and industrial sites, can minimize financial losses and offset the limited coverage provided by the NFIP.

Potential Storm Mitigation Techniques or Strategies

Following is a list of potential techniques or strategies that New Haven commercial and industrial property owners should consider to reduce risk to natural hazards. This list represents a Commercial-Industrial Toolbox that can help property owners: a) prepare for natural hazards or weather-related disasters; b) prevent damage or protect property from damaging floods; and, c) recover from damaging storms and severe flood events. Costs indicated for the techniques or tools do not include installation since that work is dependent on many variables including the type of foundation, size of building, number of floors, site elevation in floodplain, and nature of existing electrical, mechanical and plumbing systems.

1. **Raising Awareness:** Encourage building owners and operators to evaluate exposure and risk to extreme flooding events and to take action to mitigate those risks.

METHODS OF RAISING AWARENESS
• Access available Flood Insurance Rate Maps and other resources to identify a site's vulnerability to flooding at FEMA's website (**www.fema.gov**) – or from the City of New Haven (Main Library and City Plan and Building Departments located at City Hall). • Identify potential mitigation tools or techniques and conduct a benefit-cost analysis (BCA) to evaluate cost-effectiveness of on-site flood protection measures.
BENEFITS
• Enables owners to better understand and prepare for the flood risks associated with their properties. • Quantifies the net benefits of considered measures to prevent or mitigate those risks.
CHALLENGES
• Requires experience, or may require training to identify a site's vulnerabilities and to conduct a BCA.
APPROXIMATE COSTS
• The costs incurred by property owners to retain professional services to perform the BCA vary considerably depending on the size and nature of the business and its facilities.

2. **Green Infrastructure:** Using designed landscapes to collect and store stormwater runoff on a site and to filter potential contaminants suspended in stormwater runoff.

[6] FEMA, *National Flood Insurance Program, Summary of Coverage for Commercial Property.* August 2013.

TYPES OF GREEN INFRASTRUCTURE

- Bioretention ponds, bioswales and rain gardens
- Green roofs
- Pervious pavements
- Rainwater harvesting
- Tree planting

BENEFITS

- Uses natural processes to reduce and slow stormwater runoff.
- Restores groundwater recharge and reduces flooding levels in streams and rivers.
- Filters stormwater pollutants and prevents such pollutants from reaching waterways.

CHALLENGES

- Green roofs require rooftop waterproofing and structural reinforcement.
- Designed landscapes may be overwhelmed by heavy flooding events; therefore, they should be used in conjunction with other mitigation strategies.

APPLICABILITY

- A form of green infrastructure, ranging from tree planting to bioretention ponds, can be applied to all commercial and industrial parcels.
- The parcel's natural landscape (slope, soil, existing vegetation) may dictate which type is most suitable.

APPROXIMATE COSTS

- Bioretention ponds, bioswales and rain gardens: $5 - $45/square foot (sq. ft.)
- Green roofs: $10 - $20/sq. ft.
- Pervious pavements: $3 - $8/sq. ft. depending on material (pervious asphalt, pervious concrete or precast concrete unit pavers)
- Rainwater harvesting: $2,500 - $5,500 for 2,500 – 5,000-gallon tanks depending on tank material (galvanized steel, polyethylene or fiberglass).
- Tree planting: $175 - $400 per tree.

** Costs depend on site, soil, types and sizes of plants, slope of roof, needed structural reinforcement, needed rooftop reinforcements, capacity, how water will be delivered to rainwater harvesting tank (gravity flow, hose, etc.), and planned use for collected water, among other variables

Sources: A Better City: Challenge for Sustainability, "Building Resilience Toolkit," accessed April 2017: http://challengeforsustainability.org/resiliency-toolkit/; U.S. Environmental Protection Agency, "Green Infrastructure", accessed April 2017: www.epa.gov/green-infrastructure; National Oceanic Atmospheric Administration, *Green Infrastructure Options to Reduce Flooding: Definitions, Tips, and Considerations,* 2015; CT

NEMO Program, *Rain Gardens: A Design Guide for Connecticut & New England Homeowners,* accessed April 2017: http://nemo.uconn.edu/raingardens/calculator.htm. General Services Administration, *The Benefits and Challenges of Green Roofs on Public and Commercial Buildings,* May 2011. Center for Land Use Education and Research at the University of Connecticut, *Permeable Pavements for Stormwater Control.* September, 2011. Rainwater harvesting tank vendors: www.rainharvestingsupplies.com; www.rainharvest.com; www.plasticmart.com, accessed May 2017.

3. **Wet Floodproofing:** Modifying a building to withstand some exposure to floodwaters using flood openings and/or flood damage-resistant materials, while minimizing damage to the structure and its contents.

TYPES OF WET FLOODPROOFING

- Install flood openings like flood vents in the walls to allow water to pass through and to equalize the hydrostatic pressure from the floodwaters.
- Use water-resistant materials that do not need to be replaced if flooded.

BENEFITS

- Reduces the risk of flood damage to a building and its contents, even with minor mitigation.
- Greatly reduces loads on walls and floors due to equalized hydrostatic pressure.
- The cost of relocating or storing contents, except basement contents, may be eligible for flood insurance coverage, after a flood warning is issued.

CHALLENGES

- Does not satisfy the NFIP requirement for bringing substantially damaged or improved structures into compliance.
- Does not protect the building against wave action or high-velocity flood flows, and is thereby not permitted by FEMA in V Zones (Coastal High Hazard Areas) for new construction or substantial reconstruction of structures.
- Usually requires a pre-flood warning and ample time to prepare the building and contents for flooding.
- Requires human intervention to safely access and move contents from the flood-prone area.
- Results in a structure that is wet on the inside and possibly contaminated by flood-borne contaminants and other materials borne by floodwaters and may require extensive cleanup.
- Prohibits the building from being occupied during a flood and may make the structure uninhabitable for some period after flooding.
- May require additional costs to bring the structure up to compliance with current building codes.

APPROXIMATE COSTS

- Flood vents: $30 - $400 each.
- Flood damage-resistant materials: costs vary greatly depending on the size and nature of the system or building, among other variables.

Sources: FEMA, *Protecting Building Utility Systems from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems.* FEMA P-348, Edition 2, February 2017; FEMA, *Floodproofing Non-Residential Buildings.* FEMA P-936, July 2013; FEMA, *Coastal Construction Manual*. FEMA P55, Volume II, August 2011; FEMA, *Flood Damage-Resistant Materials Requirements*, Technical Bulletin 2, August 2008. FEMA, *Wet Flood Proofing Requirements*, Technical Bulletin 7-93, December 1993. Flood vent vendors: http://floodsolutions.com; https://www.floodinsurancefloodvents.com accessed: May 2017. Dodge Date & Analytics, *Smart Vent Cost Analysis,* 2012: www.construction.com/CE/articles/2012/Smart_Vent_Cost_Analysis.pdf. FEMA, *Build with Flood-Damage Resistant Materials: Protecting Your Property from Flooding,* April 2011.

4. **Elevation:** Raising the existing structure or critical building components (such as mechanical or electrical equipment) above the base flood elevation (BFE).

TYPES OF ELEVATION

- Elevate a structure on fill or on piles, piers, or columns.
- Elevate critical building components such as mechanical and electrical equipment on platforms or frames.

BENEFITS

- Protects a building or building components from flooding by raising it above the BFE.

CHALLENGES

- May require extensive site modification, structural reinforcements, and/or structural support.
- May be cost-prohibitive for existing buildings and/or buildings with sub-grade basements.
- The space below the building cannot be occupied except for use as parking, storage or building access.
- If the space below the building is enclosed, it should be wet floodproofed as well.
- Access to building and/or building components should be considered and addressed, including requirements of the Connecticut Building Code and Americans with Disabilities Act (ADA).
- Fill is not permitted by FEMA in V Zones (Coastal High Hazard Areas).

APPROXIMATE COSTS

- Costs for elevating a structure are variable.
- Raising electric components (panel, meter, outlets, switching and wiring) in a 1,000-sq. ft. structure: $1,500 - $2,000.

Sources: A Better City: Challenge for Sustainability, "Building Resilience Toolkit," accessed April 2017:

http://challengeforsustainability.org/resiliency-toolkit/; Department of City Planning, City of New York, Urban Waterfront Adaptive Strategies, June 2013; FEMA, Protecting Building Utility Systems From Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems. FEMA P-348, Edition 2, February 2017. FEMA, Raise Electrical System Components: Protecting Your Property from Flooding, April 2011.

5. **Dry Floodproofing:** Employing flood-resistant barriers or impermeable elements at openings of building to bar floodwater entry and to resist flood loads.

TYPES OF DRY FLOODPROOFING

- Install impermeable membranes and sealants applied to exterior wall faces.
- Make critical core components and areas flood-resistant if dry floodproofing the entire building footprint is not needed or is not possible.
- Install backflow valves on sewage pipes to prevent sewage from backing up into a building.
- Install structurally reinforced, portable watertight barriers (i.e., flood doors or shields) in front of (not attached to) building openings (doors, windows, garages) just prior to flood events.
- Install polished concrete flooring that is impermeable and will not need replacement after flooding.
- Where practical, permanently close any openings in the building's exterior either with brick, concrete block or glass block.

BENEFITS

- Reduces the flood risk to the structure and damage to contents.
- Less costly than other measures such as floodwalls or levees.
- Retains the structure in its present environment and may avoid significant changes in appearance.
- May be used to bring existing structures into compliance with the community's floodplain management regulations and codes.
- Can be used to protect against more frequent flooding from lesser storm events, even if it is not practical or cost-effective to floodproof to the BFE.

CHALLENGES

- Does not protect the building against wave action or high-velocity flood flows and is therefore, not permitted by FEMA in V Zones (Coastal High Hazard Areas), and is not permitted by the Connecticut State Building Code in Coastal A Zones.
- Usually requires human intervention and adequate warning time for installation of protective measures.
- May provide no protection if measures fail or are exceeded during large or long-duration floods.

- May result in more damage than flooding if design loads are exceeded, walls collapse, floors buckle, or the structure floats.
- Seepage through barriers or walls should be expected, particularly when piping, conduits, and other elements penetrate the barriers or walls.

APPROXIMATE COSTS

- Backflow valve: $600 to $1,400 depending on valve type and size.
- Aluminum flood shield: $90 - $300/ft.
- Polished concrete: $2 - $7/sq. ft.

Glass block: $400 - $1,100 per window.

Sources: FEMA, Protecting Building Utility Systems from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems. FEMA P-348, Edition 2, February 2017; FEMA, Floodproofing Non-Residential Buildings. FEMA P-936, July 2013; FEMA, Coastal Construction Manual. FEMA P55, Volume II, August 2011. FEMA, Install Sewer Backflow Valves, April 2011. San Antonio River Authority, Holistic Watershed Master Plan: Wilson, Karnes and Goliad Counties, Volume I – Flooding Issues. May 2015. Flood shield vendor: www.tmhardware.com/Door-Flood-Barrier-Shield.html, accessed: May 2017. Concrete floor vendors: www.glossyfloors.com/cost-of-polished-concrete-per-square-foot/, www.concretenetwork.com/concrete/polishing/comparison-chart.html, accessed May 2017. Modernize Home Empowerment, "Glass Block Windows" https://modernize.com/windows/types/glass-blockwindows?fpm, accessed May 2017.

6. **Secure Tanks:** Aboveground storage tanks containing fuel crucial for building operations or other materials used in manufacturing or production are especially vulnerable to floodwaters and can break away during flood events and release hazardous materials into the environment. These methods help to secure the tanks.

METHODS OF SECURE TANKS

- Install concrete base or anchors buried in the ground that have sufficient weight to resist flood waters; secure tanks to anchors with metal straps.
- Mount tanks on wheels to enable relocation to higher ground prior to flood events
- Locate tanks in dry, flood-proofed enclosures.

BENEFITS

- Prevents flotation during flooding flood events, thereby minimizing damage and contamination.

CHALLENGES

- In V Zones (Coastal High Hazard Areas), aboveground storage tanks are not permitted under elevated buildings or attached to buildings below the lowest floor.
- In coastal areas, anchors should be made of corrosion-resistant materials to avoid salt spray damage.

APPROXIMATE COSTS

- Anchoring a 1,000-gallon fuel tank to a concrete base: $300 - $500.

Sources: FEMA, Protecting Building Utility Systems from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems. FEMA P-348, Edition 2, February 2017; FEMA, Anchor Fuel Tanks: Protecting Your Property from Flooding. April 2011

7. **System backup:** Alternative energy systems to enable a building's power networks to continue to operate during emergencies.

METHODS OF SYSTEM BACKUPS

- Install combined heat and power (CHP) generators such as reciprocating engines, steam turbines, microturbines, fuel cells, combustion turbines.
- Install batteries for emergency applications.
- Install a microgrid for local power users.

BENEFITS

- Maintains power in isolation, even when overall power grid is off-line; thereby preventing service interruptions.
- Provides reduction in energy costs and emissions.
- CHP generators are highly efficient and offer greater reliability than conventional diesel generators.

CHALLENGES

- Should be installed in conjunction with floodproofing techniques (such as elevating the generators above the BFE).
- Requires periodic testing to ensure serviceability.
- Batteries have finite supply of power which may run out during extended flooding events.
- High-capacity batteries can be large.
- Microgrids may not be the most environmentally-friendly option, depending on fuel source, and would require new electrical infrastructure.

APPROXIMATE COSTS

- Reciprocating engine: $1,400 - $2,900/kilowatt (kW).
- Steam turbine: $650 - $1,150/kW.
- Microturbine: $2,500 - $4,300/kW.
- Fuel cell: $4,600 - $23,000/kW.
- Combustion turbine: $1,250 - $3,300/kW.
- Batteries: $255 - 300/kW.
- Microgrid: $1M - $2.5M.

Sources: FEMA, Floodproofing Non-Residential Buildings. FEMA P-936, July 2013; U.S. Environmental Protection Agency (EPA) Combined Heat and Power Partnership, "CHP Benefits," accessed April 2017: https://www.epa.gov/chp/chp-benefits; EPA Combined Heat and Power Partnership, Catalog of CHP Technologies, March 2015 https://www.epa.gov/chp/catalog-chp-technologies, accessed April 2017. National Renewable Energy Laboratory, Economic Analysis Case Studies of Battery Energy Storage with SAM, 2016 http://www.nrel.gov/docs/fy16osti/64987.pdf; KEMA Inc, Microgrids – Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts, 2014 http://files.masscec.com/research/Microgrids.pdf.

8. **Internal drainage system:** To collect and discharge floodwaters from a basin within a building into the sewer system.

METHODS OF INTERNAL DRAINAGE SYSTEMS

- Install basins and sump pumps in areas where floodwater could accumulate.

BENEFITS

- Provides drainage for increased water leakage due to flooding events.

CHALLENGES

- Should be combined with other dry floodproofing and system backup measures, so as to protect the electrical system supplying the sump pump.
- Heavy flooding can overwhelm pumping capacity.
- Per 412.5 of the 2012 International Plumbing Code portion of the 2016 Connecticut State Building Code, floor drains shall not be connected to the storm sewer system.
- Requires care when pumping out basements to avoid foundation wall collapse.
- Requires periodic testing and routine maintenance to ensure running properly.
- NFIP requires sump pump installation when dry floodproofing is used as a retrofit technique.

APPROXIMATE COSTS

- Sump pump: $200 - $3,500

Sources: FEMA, Floodproofing Non-Residential Buildings. FEMA P-936, July 2013; Sump pump vendor: www.grainger.com, accessed May 2017; Dodge Date & Analytics, Smart Vent Cost

Analysis, 2012:
www.construction.com/CE/articles/2012/Smart_Vent_Cost_Analysis.pdf.

Applicable State and City Codes

The Connecticut State Building Code (CSBC), adopted October 2016, is based on the 2012 International Building Code (IBC) from the International Code Council. Per Section 1612.4, design and construction of buildings and structures located in flood hazard areas must be in accordance with the American Society of Civil Engineers (ASCE) *Minimum Design Loads for Buildings and Other Structures* (ASCE 7) and *Flood Resistant Design and Construction* (ASCE 24). ASCE 7 describes how buildings in flood hazard areas can be designed to resist flood loads. ASCE 24 prescribes a number of strategies to enhance structural resiliency in flood hazard areas – these measures meet or exceed the minimum NFIP requirements. Thus, several of the mitigation strategies listed above are mandated or restricted by the building code. For instance, dry floodproofing measures are not permitted for non-residential buildings in several flood hazard sub-areas (such as Coastal Zone A or Zone V).

In addition to the CSBC, the City of New Haven adopted the Floodplain Damage Prevention Ordinance in 2013 to reflect newly updated FEMA Flood Insurance Rate Maps (FIRMs). This ordinance established the Floodplain Development Permit, which is required for any development within the floodplain. In addition, specific mitigation measures may be subject to additional regulations and permits. For instance, installation of green infrastructure could be dictated by Section 60 (Stormwater Management Plans) of the City's Zoning Ordinance and Chapter 26 (Stormwater Discharges) of the City's Code of Ordinances.

6. Final Project Schedule and Budget

Project Task	**Date**
Aldermanic Resolution Approved	1/14/16
Grant Awarded	4/6/16
Consultants Hired	2/1/17
First Stakeholder Meeting	3/13/17
Second Stakeholder Meeting	4/25/17
Grant Extension Awarded	5/30/17
Technical Memo and Brochure Developed	6/21/17
Final Deliverable to CIRCA	7/31/17

Total Budget

The CIRCA Municipal Resilience Grant Program required partial municipal funding for this project, and so the City of New Haven contributed $10,000.

	CIRCA	**Local Match**	**Total**
1) Discovery and Research	$7,500	$2,500	$10,000
2) Protocol Development	$4,500	$0	$4,500
3) Stakeholder Meetings and Workshops	$2,000	$5,000	$7,000
4) Report and Presentation Materials	$4,000	$2,500	$6,500
5) Outreach	$2,000	$0	$2,000
TOTAL	**$20,000**	**$10,000**	**$30,000**

7. Conclusion

The CIT aimed to educate commercial and industrial stakeholders and to prepare them for the increasing coastal risk. Meetings with at-risk stakeholders were conducted to inform them of their risk and to provide already available resources to them. While outreach efforts have already been significant, the City will distribute the brochure and poster it designed in this project to realtors, businesses, and industries. The CIT is unique because it addresses primarily the built environment as opposed to just the natural environment of the city.

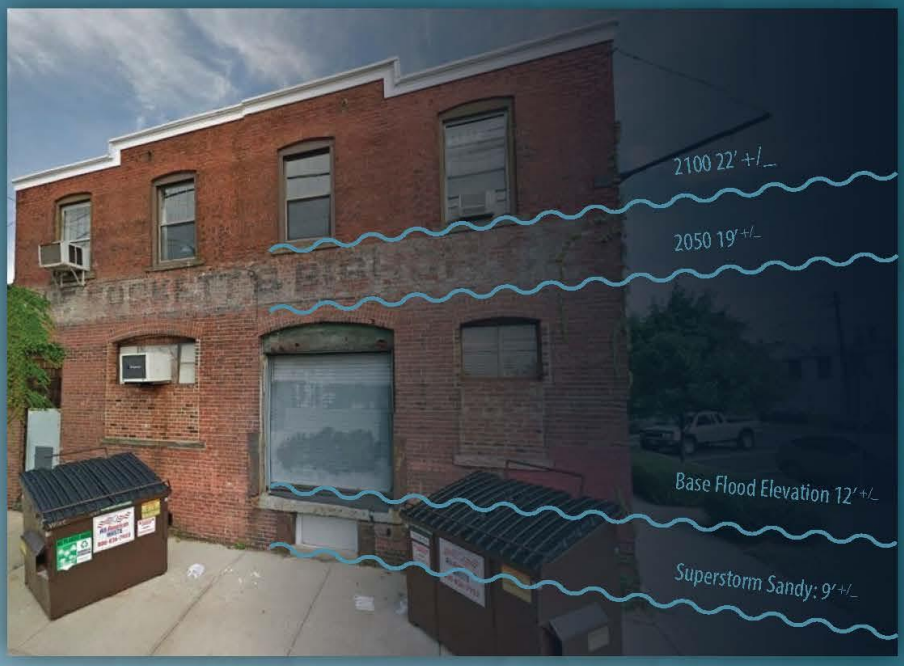
8. APPENDICES

APPENDIX A
CIT Brochure

City of New Haven

Commercial Industrial Toolbox

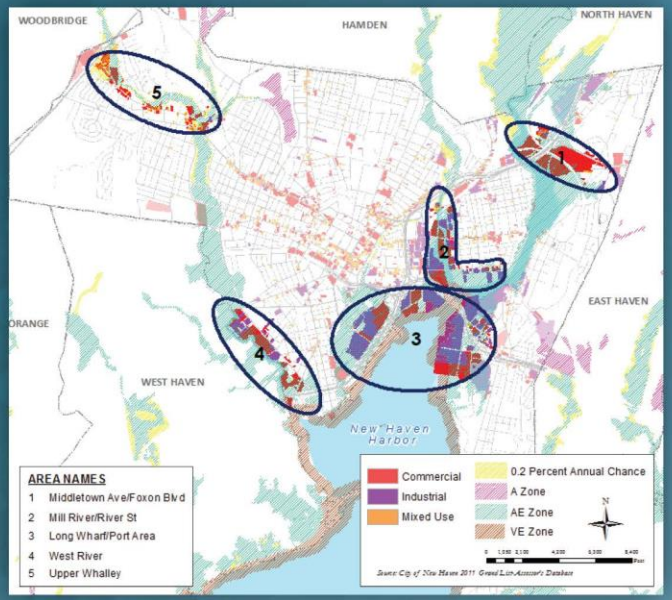
Project Objectives



- To promote resilient construction and renovation techniques applicable to commercial and industrial properties within flood-prone areas.
- To implement some of the goals of the New Haven Hazard Mitigation Plan, which focuses on strategies that can serve to reduce or prevent damages from future flood and storm surge events, restore economic losses as quickly as possible, and raise public awareness about flood-related risks.
- To protect life and property, and minimize, if not entirely prevent, temporary loss of business operations due to flooding.
- To develop techniques or strategies that can be replicated throughout the state.

Overview of Vulnerable Commercial and Industrial Properties

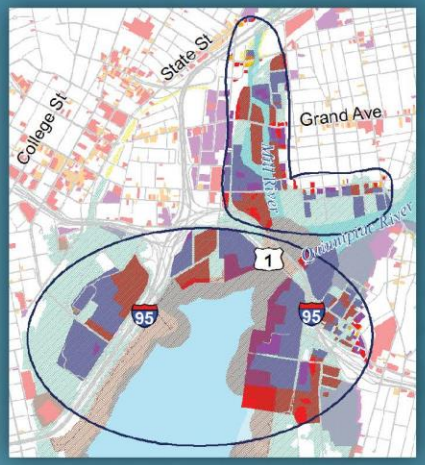
- There are approximately 2,875 commercial buildings within New Haven = nearly $6 billion of building value.[1]
- Commercial and industrial uses account for > 29% of existing land use in the city,[2] and are predominantly found within 5 areas that are particularly vulnerable to riverine and coastal flooding, as shown here.
- The total potential economic loss from a 100-year riverine flood and a 100-year coastal flood event are projected to be nearly $32.9 million[3] and $176.6 million respectively, for commercial and industrial businesses.[4]
- The National Flood Insurance Program (NFIP) is a voluntary program, administered by the Federal Emergency Management Agency (FEMA), through which property owners in participating communities can purchase Federal flood insurance as a protection against flood losses.
- The NFIP offers commercial policyholders coverage for < $500,000 each for building property and contents of the business; property outside of a building and business interruption losses are not covered.[5]
- Incorporating flood damage mitigation strategies into commercial and industrial sites can minimize financial losses and help offset the limited coverage provided by the NFIP.



Area 1: Middletown Avenue/ Foxon Boulevard

- Northeast corner of the city
- Lies within floodplains associated with the Quinnipiac River
- Prone to flooding due to its low-lying and flat topography and the size of the Quinnipiac River watershed that lies up-river, well beyond City limits

[1] City of New Haven, *Draft Natural Hazard Mitigation Plan Update*, October 2016
[2] Ibid.
[3] Total includes municipal losses as well.
[4] City of New Haven, *Draft Natural Hazard Mitigation Plan Update*, October 2016
[5] FEMA, *National Flood Insurance Program, Summary of Coverage for Commercial Property*. August 2013.

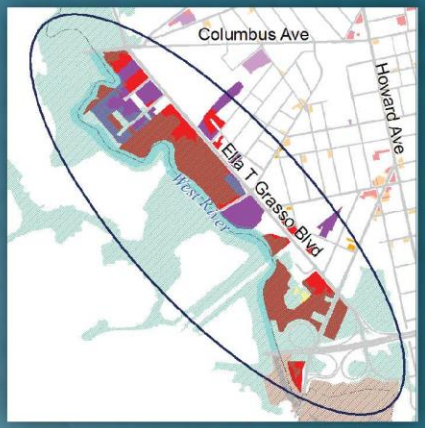


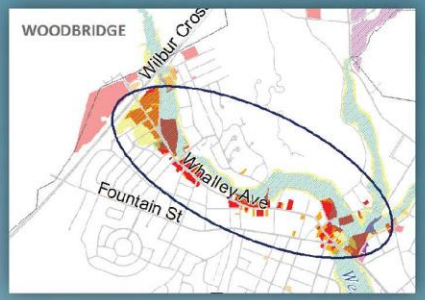
Areas 2: Mill River/River Street and Area 3: Long Wharf/Port Area

- Situated around New Haven Harbor
- Prone to both riverine and coastal flooding
- Lie within floodplains associated with the Mill and Quinnipiac Rivers, as well as coastal hazard areas associated with Long Island Sound

Area 4: West River

- Southwest corner of the city, concentrated along Ella T. Grasso Boulevard
- Lies within floodplains associated with the West River
- The southern portion of the district, closer to New Haven Harbor, is located within a velocity hazard area and is prone to coastal flooding and storm surges.
- In recent years, the area's susceptibility to flooding has been reduced due to the installation of self-regulating tide gates, as well as recent tidal marsh and channel restoration projects.





Area 5: Upper Whalley

- Northwestern New Haven, situated along the West River
- Characterized by a mix of commercial and residential uses
- Located within floodplains associated with the West River

Applicable State and City Codes:

The Connecticut State Building Code (CSBC), adopted October 2016, is based on the 2012 International Building Code (IBC) from the International Code Council. Per Section 1612.4, design and construction of buildings and structures located in flood hazard areas must be in accordance with the American Society of Civil Engineers (ASCE) *Minimum Design Loads for Buildings and Other Structures* (ASCE 7) and *Flood Resistant Design and Construction* (ASCE 24). ASCE 7 describes how buildings in flood hazard areas can be designed to resist flood loads. ASCE 24 prescribes a number of strategies to enhance structural resiliency in flood hazard areas – these measures meet or exceed the minimum NFIP requirements. Thus, several of the mitigation strategies listed above are mandated or restricted by the building code. For instance, dry floodproofing measures are not permitted for non-residential buildings in several flood hazard sub-areas (such as Coastal Zone A or Zone V).

In addition to the CSBC, the City of New Haven adopted the Floodplain Damage Prevention Ordinance in 2013 to reflect newly updated FEMA Flood Insurance Rate Maps (FIRMs). This ordinance established the Floodplain Development Permit, which is required for any development within the floodplain. In addition, specific mitigation measures may be subject to additional regulations and permits. For instance, installation of green infrastructure could be dictated by Section 60 (Stormwater Management Plans) of the City's Zoning Ordinance and Chapter 26 (Stormwater Discharges) of the City's Code of Ordinances.

Resources for Property Owners:

Following is a list of potential techniques or strategies that New Haven commercial and industrial property owners should consider to reduce risk to natural hazards. This list represents a Commercial-Industrial Toolbox that can help property owners:

a. Prepare for natural hazards or weather-related disasters;

b. Prevent damage or protect property from damaging floods; and,

c. Recover from damaging storms and severe flood events.

Costs indicated for the techniques or tools do not include installation since that work is dependent on many variables including the type of foundation, size of building, number of floors, site elevation in floodplain, and nature of existing electrical, mechanical and plumbing systems.

1. Raising Awareness:

Encourage building owners and operators to evaluate exposure and risk to extreme flooding events and to take action to mitigate those risks.

Methods of Raising Awareness

- Access available FIRMs and other resources to identify a site's vulnerability to flooding at FEMA website - www.fema.gov - or from the City of New Haven (Main library and City Plan and Building Departments located at City Hall).
- Identify potential mitigation tools or techniques and conduct a benefit-cost analysis (BCA) to evaluate cost-effectiveness of on-site flood protection measures.

Benefits

- Enables owners to better understand and prepare for the flood risks associated with their properties.
- Quantifies the net benefits of considered measures to prevent or mitigate those risks.

Challenges

- Requires experience, or may require training to identify a site's vulnerabilities and to conduct a BCA.

Approximate Costs

- The costs incurred by property owners to retain professional services to perform the BCA vary considerably depending on the size and nature of the business and its facilities.

2. Green Infrastructure:

Green Infrastructure: Using designed landscapes to collect and store stormwater runoff on a site and to filter potential contaminants suspended in stormwater runoff.

Types of Green Infrastructure

- Bioretention ponds, bioswales and rain gardens
- Green roofs
- Pervious pavements
- Rainwater harvesting
- Tree planting

Benefits

- Uses natural processes to reduce and slow stormwater runoff.
- Restores groundwater recharge and reduces flooding levels in streams and rivers.
- Filters stormwater pollutants and prevents such pollutants from reaching waterways.

Challenges

- Green roofs require rooftop waterproofing and structural reinforcement.
- Designed landscapes may be overwhelmed by heavy flooding events; therefore, they should be used in conjunction with other mitigation strategies.

Approximate Costs

- Bioretention ponds, bioswales and rain gardens: $5 - $45/square foot (sq. ft.)
- Green roofs: $10 - $20/sq. ft.
- Pervious pavements: $3- $10/sq. ft. depending on material (pervious asphalt, pervious concrete or precast concrete unit pavers)
- Rainwater harvesting: $2,500 to $5,500 depending on tank material (galvanized steel, polyethylene or fiberglass) and tank size.
- Tree planting: $175 - $400 per tree.

**Costs depend on site, soil, types and sizes of plants, slope of roof, needed structural reinforcement, needed rooftop reinforcements, capacity, how water will be delivered to rainwater harvesting tank (gravity flow, hose, etc.), and planned use for collected water, among other variables.

City of New Haven is installing 200 bioswales throughout the city. Photo of Edgewood School Bioswale

Sources: A Better City: Challenge for Sustainability, "Building Resilience Toolkit," accessed April 2017; http://challengeforsustainability.org/resilience-toolkit/; U.S. Environmental Protection Agency, "Green Infrastructure", accessed April 2017; www.epa.gov/green-infrastructure; National Oceanic Atmospheric Administration, *Green Infrastructure Options to Reduce Flooding: Definitions, Tips, and Considerations*, 2015; CT NEMO Program, *Rain Gardens: A Design Guide for Connecticut & New England Homeowners*, accessed April 2017; http://nemo.uconn.edu/raingardens/calculator.htm; General Services Administration, *The Benefits and Challenges of Green Roofs on Public and Commercial Buildings*, May 2011. Center for Land Use Education and Research at the University of Connecticut, *Permeable Pavements for Stormwater Control*, September, 2011. Rainwater harvesting tank vendors: www.rainharvestingsupplies.com; www.rainharvest.com; www.plastic-mart.com, accessed May 2017.

3. Wet Floodproofing:

Modifying a building to withstand some exposure to floodwaters using flood openings and/or flood damage-resistant materials, while minimizing damage to the structure and its contents.

Types of Wet Floodproofing

- Install flood openings like flood vents in the walls to allow water to pass through and to equalize the hydrostatic pressure from the floodwaters.
- Use water-resistant materials that do not need to be replaced if flooded.

Benefits

- Reduces the risk of flood damage to a building and its contents, even with minor mitigation.
- Greatly reduces loads on walls and floors due to equalized hydrostatic pressure.
- The cost of relocating or storing contents, except basement contents, may be eligible for flood insurance coverage, after a flood warning is issued.

Challenges

- Does not satisfy the NFIP requirement for bringing substantially damaged or improved structures into compliance.
- Does not protect the buildings located in V Zones against wave action or high-velocity flood flows, and is not permitted by FEMA in V Zones (Coastal High Hazard Areas) for new construction or substantial reconstruction of structures.
- Usually requires a pre-flood warning and ample time to prepare the building and contents for flooding.
- Requires human intervention to safely access and move contents from the flood prone area.
- Results in a structure that is wet on the inside and possibly contaminated by flood-borne contaminants and other materials borne by floodwaters and may require extensive cleanup.
- Prohibits the building from being occupied during a flood and may make the structure uninhabitable for some period after flooding.
- May require additional costs to bring the structure up to compliance with current building codes.

Approximate Costs

- Flood vents: $30 - $400 each.
- Flood damage-resistant materials: costs vary greatly , depending on the size and nature of the system or building, among other variables.

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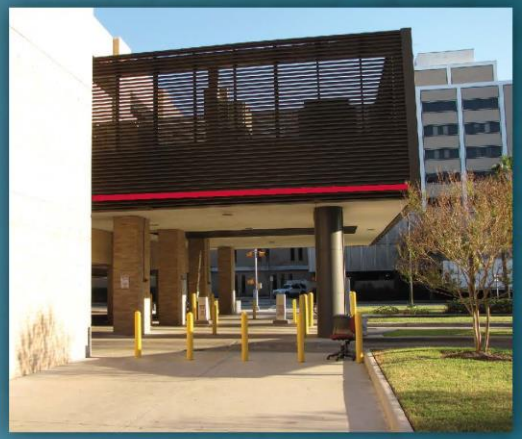
4. Elevation:

Raising the existing structure or critical building components (such as mechanical or electrical equipment) above the base flood elevation (BFE).



Types of Elevation

- Elevate a structure on fill or on piles, piers, or columns.
- Elevate critical building components such as mechanical and electrical equipment on platforms or frames.

Benefits

- Protects a building or building components from flooding by raising it above the BFE.

Challenges

- May require extensive site modification, structural reinforcements, and/or structural support.
- May be cost-prohibitive for existing buildings and/or buildings with sub-grade basements.
- The space below the building cannot be occupied except for use as parking, storage or building access.
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- Fill is not permitted by FEMA in V Zones (Coastal High Hazard Areas).

Approximate Costs

- Costs for elevating a structure are variable.
- Raising electric components (panel, meter, outlets, switching and wiring) in a 1,000-sq. ft. structure: $1,500 - $2,000.

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5. Dry Floodproofing:

Employing flood-resistant barriers or impermeable elements at openings of building to bar floodwater entry and to resist flood loads.

Types of Dry Floodproofing

- Install impermeable membranes and sealants applied to exterior wall faces.
- Make critical core components and areas flood-resistant if dry floodproofing the entire building footprint is not needed or is not possible.
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- Install structurally reinforced, portable watertight barriers (i.e., flood doors or shields) in front of (not attached to) building openings (doors, windows, garages) just prior to flood events.
- Install polished concrete flooring that is impermeable and will not need replacement after flooding.
- Where practical, permanently close any openings in the building's exterior either with brick, concrete block or glass block.

Benefits

- Reduces the flood risk to the structure and damage to contents.
- Less costly than other measures such as floodwalls or levees.
- Retains the structure in its present environment and may avoid significant changes in appearance.
- May be used to bring existing structures into compliance with the community's floodplain management regulations and codes.
- Can be used to protect against more frequent flooding from lesser storm events, even if it is not practical or cost-effective to floodproof to the BFE.

Challenges

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- Seepage through barriers or walls should be expected, particularly when piping, conduits, and other elements penetrate the barriers or walls.

Approximate Costs

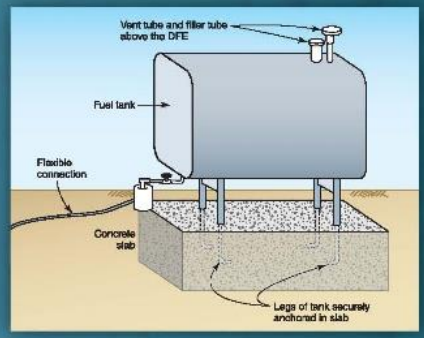
- Backflow valve: $600 to $1,400 depending on valve type and size.
- Aluminum flood shield: $90 - $300/ft.
- Polished concrete: $2 - $7/sq. ft.
- Glass block: $400 - $1,100 per window.

Sources: FEMA, *Protecting Building Utility Systems from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems*, FEMA P-348, Edition 2, February 2017; FEMA, *Floodproofing Non-Residential Buildings*, FEMA P-936, July 2013; FEMA, *Coastal Construction Manual*, FEMA P-55, Volume II, August 2011; FEMA, *Install Sewer Backflow Valves*, April 2011; San Antonio River Authority, *Skillkit: Watershed Master Plan: Wilson, Karnes and Goliad Counties, Volume I – Flooding Issues*.

May 2015, Flood shield vendor: [redacted], accessed: May 2017. Concrete floor vendors: [redacted], accessed May 2017; Modernize Home Improvement, "Glass Block Windows" [redacted], accessed May 2017.

6. Secure Tanks:

Exterior tanks containing fuel crucial for building operations or other materials used in manufacturing or production are especially vulnerable to floodwaters and can break away during flood events and release hazardous materials into the environment. These methods help to secure the tanks.



Methods to Secure Tanks

- Install concrete base or anchors buried in the ground that have sufficient weight to resist flood waters; secure tanks to anchors with metal straps
- Mount tanks on wheels to enable relocation to higher ground prior to flood events
- Locate tanks in dry, flood-proofed enclosures.

Benefits

- Prevents flotation during flooding flood events, thereby minimizing damage and contamination.

Challenges

- In V Zones (Coastal High Hazard Areas), aboveground storage tanks are not permitted under elevated buildings or attached to buildings below the lowest floor.
- In coastal areas, anchors should be made of corrosion-resistant materials to avoid salt spray damage.

Approximate Costs

- Anchoring a 1,000-gallon fuel tank to a concrete base: $300 - $500.

Sources: FEMA, Protecting Building Utility Systems from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems. FEMA P-348, Edition 2, February 2017; FEMA, Anchor Fuel Tanks, Protecting Your Property from Flooding, April 2011.

7. System Backup:

Alternative energy systems to enable a building's power networks to continue to operate during emergencies.

Methods of System Backups

- Install combined heat and power (CHP) generators such as reciprocating engines, steam turbines, microturbines, fuel cells, combustion turbines.
- Install batteries for emergency applications.
- Install a microgrid for local power users.

Benefits

- Maintains power in isolation, even when overall power grid is off-line; thereby preventing service interruptions.
- Provides reduction in energy costs and emissions.
- CHP generators are highly efficient and offer greater reliability than conventional diesel generators.

Challenges

- Should be installed in conjunction with floodproofing techniques (such as elevating the generators above the BFE).
- Requires periodic testing to ensure serviceability.
- Batteries have finite supply of power which may run out during extended flooding events.
- High-capacity batteries can be large.
- Microgrids may not be the most environmentally-friendly option, depending on fuel source and require new electrical infrastructure.

Approximate Costs

- Reciprocating engine: $1,400 - $2,900/kilowatt (kW).
- Steam turbine: $650 - $1,150/kW.
- Microturbine: $2,500 - $4,300/kW.
- Fuel cell: $4,600 - $23,000/kW.
- Combustion turbine: $1,250 - $3,300/kW.
- Batteries: $255 - 300/kW.
- Microgrid: $1M - $2.5M.

Sources: FEMA, *Floodproofing Non-Residential Buildings*, FEMA P-936, July 2013; U.S. Environmental Protection Agency (EPA) Combined Heat and Power Partnership, "CHP Benefits," accessed 3 April 2017; https://www.epa.gov/chp/chp-benefits; EPA Combined Heat and Power Partnership, *Catalog of CHP Technologies*, March 2015; https://www.epa.gov/chp/catalog-chp-technologies, accessed April 2017. National Renewable Energy Laboratory, *Economic Analysis Case Studies of Battery Energy Storage with SAM*, 2016; KEMA Inc, *Microgrids – Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts*, 2014;

8. Internal Drainage System:

To collect and discharge floodwaters from a basin within a building into the sewer system.

Methods of Internal Drainage Systems

- Install basins and sump pumps in areas where floodwater could accumulate.

Benefits

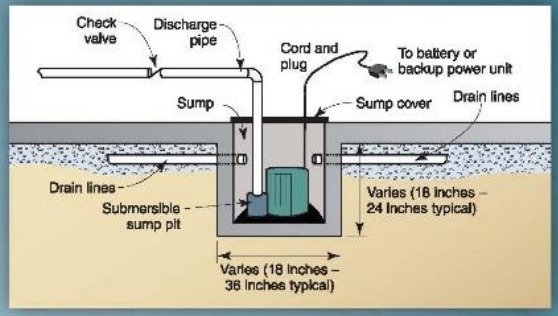
- Provides drainage for increased water leakage due to flooding events.

Challenges

- Should be combined with other dry floodproofing and system backup measures, so as to protect the electrical system supplying the sump pump.
- Heavy flooding can overwhelm pumping capacity.
- Per 412.5 of the 2012 International Plumbing Code portion of the 2016 Connecticut State Building Code, floor drains shall not be connected to the storm sewer system.
- Requires care when pumping out basements to avoid foundation wall collapse.
- Requires periodic testing and routine maintenance to ensure running properly.
- NFIP requires sump pump installation when dry floodproofing is used as a retrofit technique.

Approximate Costs

- Sump pump: $200 - $3,500



Sources: FEMA, *Floodproofing Non-Residential Buildings*, FEMA P-936, July 2013; Sump pump vendor: [illegible], accessed May 2017; Dodge Data & Analytics, *Smart Vent Cost Analysis*, 2012;

Modern Manufacturing Facility

"Dry Floodproofing" such as polished concrete flooring with impermeable sealant could be installed to resist damage from floodwaters and make clean-up easier.

"Dry Floodproofing" such as impermeable sealants can be applied to exterior walls.

"System Backup" such as providing backup electrical and communications systems in ceilings to take over if conduits in floor slabs are flooded can help keep businesses in operation immediately after flood events.

"Internal Drainage Systems" should be installed in basement storage areas

The "Elevation" of critical infrastructure above flood elevations, will ensure that building systems and operations can be quickly restored after a flood event.

Historic Manufacturing or Warehouse Facility

"Internal Drainage Systems" could be installed in basement storage areas

"Wet Floodproofing," such as louvered vents, could be installed in openings leading to basement or crawl space to improve the building's ability to withstand hydrostatic pressure caused by floodwaters.

"Dry Floodproofing" technique to brick over windows was installed; alternatively, glass block could also be used to bar flood waters while allowing light to permeate into building.

"Dry Floodproofing" such as impermeable sealants can be applied to exterior walls.

"Dry Floodproofing" such as portable flood resistant barriers could be installed at ground-level doors and other openings to bar floodwater entry.

Small Commercial or Retail Facility

"Dry Floodproofing" such as portable flood resistant barriers could be installed at depressed truck loading areas to bar floodwater entry.

"Dry Floodproofing" such as impermeable sealants can be applied to exterior walls.

The "Elevation" of this new restaurant and its critical infrastructure were constructed above flood elevations, while maintaining ADA access from parking areas.

"Secure Tanks" to buried concrete bases or other anchors to resist floodwaters and avoid spillage of hazardous materials into the environment.

Modern Showroom and Warehouse/Distribution Facility

"Green Infrastructure" such as bioswales, pervious pavements, rain gardens and tree plantings can help reduce stormwater runoff and reduce potential for flooding from lesser storm events.

"Dry Floodproofing" such as impermeable sealants can be applied to exterior walls.

"System Backup" such as providing backup electrical and communications systems in ceilings to take over if conduits in floor slabs are flooded can help keep businesses in operation immediately after flood events.

"Internal Drainage Systems" could be installed in basement storage areas.

"Dry Floodproofing" such as portable flood resistant barriers could be installed at depressed truck loading areas to bar floodwater entry.

"Dry Floodproofing" such as polished concrete flooring with impermeable sealant could be installed to resist damage from floodwaters and make clean-up easier.

APPENDIX B
CIT Poster

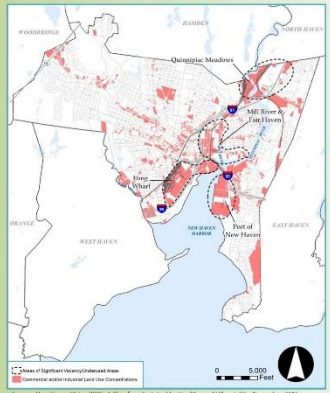
City of New Haven
Commercial Industrial Toolbox (CIT)

CIRCA
Connecticut Institute for Resilience and Climate Adaptation

Purpose and Scope

- To provide a comprehensive and practical guide for **resilient renovation/construction in commercial and industrial areas of the city, which may be replicated in other commercial/industrial areas in Connecticut.**
- To protect lives and property and prevent temporary loss of business in commercial/industrial areas of the city due to flooding by identifying case studies of similar initiatives throughout the country and recommending mitigation strategies that are best applicable to New Haven.
- To further serve the mission of the Program for Public Information (PPI) of FEMA's Community Rating System program by educating commercial/industrial stakeholders on how to prepare, adapt and quickly recover from major flooding events.

Commercial and Industrial Concentrations within New Haven



Source: *New Haven Vision 2025, A Plan for a Sustainable, Healthy, and Vibrant City*, November 2015.

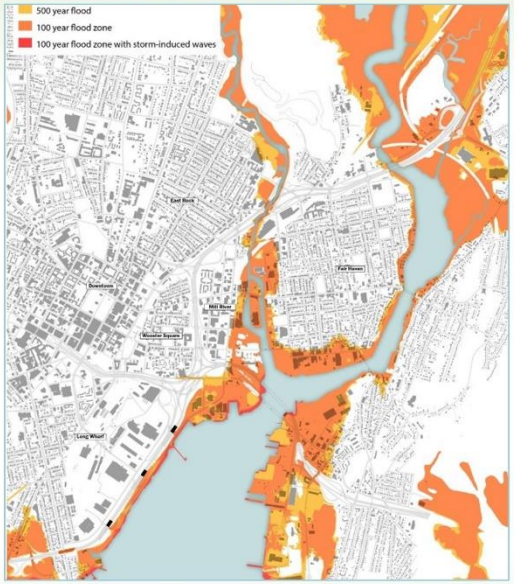
Approximately **$6 billion** of commercial building value exists within New Haven. Many of the city's large scale commercial/industrial parcels are located in Long Wharf and Mill River neighborhoods by the waterfront.

An estimated **$175 million** of commercial and industrial building-related losses, and **$139 million** of commercial and industrial business interruption losses are potentially threatened by 100-year coastal flood event if they are not protected.

Source: *City of New Haven HMP Update II Draft, 2016*

Timeline for CIT Project Completion

Flood Hazard Areas of New Haven



Sources: *Mill River District Planning Study, New Haven, Connecticut, June 2013*

Why Is CIT necessary?

Source: *National Oceanic and Atmospheric Administration Sea Level Rise (SLR) Projections*

Flooding near IKEA in Long Wharf Due to a Storm in August 2012

Sample Mitigation Strategies

Elevation: Raising existing structures or building components to equal or greater than the base flood elevation. Raising grade for new buildings.

Relocation: Moving existing structures or building components to outside the floodplain or to a higher level or higher floor within the building.

Dry Floodproofing: Employing flood-resistant barriers to protect a building against floods of limited duration and depth, such as impermeable walls, sealing openings, and enhancing the drainage system.

Wet Floodproofing: Modifying a building so as to withstand some exposure to floodwaters, such as raising utilities to or above the base flood elevation level, installing flood openings to equalize the pressure from the floodwaters, and using water-resistant materials.

Other: To be identified as part of the study.

APPENDIX C
Copies of Sign-in Sheets and Meeting Notes

Meeting Attendance

City of New Haven, Commercial Industrial Toolbox

Stakeholder Meeting

Location: EDC of New Haven Conference Room, 545 Long Wharf Drive, 4th Floor, New Haven, CT
Monday, March 13, 2017, 1:00 P.M.

Check if in Attendance	Name	Organization	Phone	Email
✓	Susmitha Attota, AICP	Assistant Director of Comprehensive Planning, New Haven City Plan Department	203-946-7814	sattota@newhavenct.gov
	Dave Sousa	CDM Smith	203-865-2191	sousad@cdmsith.com
	JED BACKUS	Backus Real Estate / NHMR CID	(203)230-1077	jed@backusre.com
	Daniel O'Neill	City of New Haven, Deputy Building Inspector	203-946-8048	doneill@newhavenct.gov
	~~Susmitha Attota~~			
	MaryEllen McMahon	Hummel Bros., Inc.	(203)787-4113	mehummel@AOL.com
	JEFF ZEITLIN	IKEA	203-672-1161	JEFFREY.ZEITLIN@IKEA.COM
	Tom Adams	RWA	203-401-2541	TADAMS@RWATER.COM
	Carlos Eyzaguirre	City of NHV, E.D. Officer	X5761	CEyzaguirre@newhavenct.gov
	Steve Fontana	"	203-946-5891	SFontana@newhavenct.gov

DRAFT

Report of Meeting

Project: New Haven Commercial-Industrial Toolbox

Subject of Meeting: First Stakeholder Meeting

Location of Meeting: EDC Headquarters, 545 Long Wharf, New Haven

Date/Time of Meeting: March 13, 2017; 1:00 P.M.

Attendees: See sign-in sheet

Marry Ellen McMahan	Hummel Bros. Inc.	203-787-4113	mehummel@aol.com
Jed Backus	Backus Real Estate/ NHMR CID	203-230-1077	jed@backus.com
Jeff Zeitlin	IKEA	203-672-1161	Jeffrey.zeitlin@ikea.com
Daniel O'Neill	City of New Haven, Deputy Building Inspector	203-946-8048	doneill@newhavenct.gov
Tom Adamo	Regional Water Authority	203-401-2541	tadamo@rwater.com
Carlos Eyzaguirre	City of New Haven, E.D. Officer	203-946-5761	ceyzaguirre@newhavenct.gov
Steve Fontana	Deputy Economic Development Director	203-946-5891	sfontana@newhavenct.gov
Susmitha Attota	Asst. Dir. Of Comprehensive Planning, New Haven City Plan Dept.	203-946-7814	sattota@newhavenct.gov
Dave Sousa	Senior Planner, CDM Smith	860-808-2261	sousad@cdmsmith.com

Summary of Discussion:

1. Have business operations been interrupted due to flood damage?
    a. Ikea: Not aware of specific flood damage, their site is susceptible to flash flooding in parking lot esp. near Brewery Street. Storm Sandy caused such parking flooding. Some water seeped in on NE side at emergency exits.
    b. Regional Water Authority also had damage in parking lots during Sandy and they evacuated equipment and vehicles to another location.
    c. Hummel: Site has occasional flooding to parking areas.
    d. Neither Ikea and Hummel had business disruptions due to flooding.
2. Were you previously aware of the National Flood Insurance Program (NFIP) and the Community Rating System (CRS)?
    a. General knowledge of FEMA but limited knowledge of how CRS helps lower insurance premiums. Do insurance underwriters know that these discounts are available? Yes, City makes them available and notifies insurance companies.
3. Are you aware of other resources?
    a. The Association for State Flood Plain Managers has a lot of information on their website.

4. Do you think that the City or State should do more to assist property owners with resources? What specifically?
    a. City has reverse 911 to alert property owners. But property owners need to sign up for it? Check with City's emergency management website.
    b. Property owners need more options for insurance as well as education on modifications to properties to mitigate flood damage.
    c. Private property insurance doesn't cover anything related storms – also does not cover damage to inventory.
5. Have you employed/constructed any mitigation strategies on your property, if so, what specifically?
    a. McDonalds on Kimberly Ave. has constructed flood improvements – building is supposed to be above base flood elevation (BFE, aka the 100-year storm), not possible so they flood-proofed the building with drains and back flow preventers and manually installed barriers that they can roll-out at doorways. The nearby Popeyes has done similar work.
    b. New Haven regulatory flood elevation is based on the BFE but requires and additional one foot of freeboard.
    c. FEMA might be issuing new requirement that requires properties located within the limits of the 500-year storm (0.2% chance of flooding in a given year) to get flood insurance.
    d. Shell and Bones Restaurant in Mill River received major damage in recent storms – they have since elevated all their mechanical equipment but did not have to do the building.
    e. The City conducted extensive outreach post Sandy; the EDC's Clay Williams has spreadsheet of all properties that were damaged during Sandy and Irene.
6. Would you be willing to share any pre- and post-flood pictures of your property?
    a. Talk with ServePro, they rehab properties post-flooding and might have photos.
7. How can the CIT be most helpful to you and your needs?
    a. Attendees will think about this question and email the City with any ideas.
8. What would be the best strategy to get the word out on the CIT?
    a. Contact Greater New Haven Chamber of Commerce.

b. Jed could share information on the CIT with the commercial -brokerage community, esp. to quantify storm mitigation costs, assess insurance costs etc.

c. IKEA could place brochures in the employee room, but to provide in store, they would need to get permission from upper management.

9. Who else should we include as a stakeholder?

    a. Jerry Klupper from NHV Manufacturing Association.

    b. Long Wharf Business Association has about 70 names on it.

Submitted by:
CDM Smith, David V. Sousa

Distribution: (by email only)

C.I.T. SIGN-IN SHEET 4/25/17

NAME	AFFILIATION	EMAIL
DAVE SOUSA	CDM SMITH	SOUSAD@CDMSMITH.COM
Josh Bernstein	Long Wharf Theatre	joshua.bernstein@longwharf.org
Jed Bickus	Bickus Real Estate Realtors	jed@bickusre.com
Tommy Adamo	Regional Water	tadamo@rwater.com
FereshtehBekhrad	RiverFrontDevelopmentLLC	FBEKHRAD@AOL.Com
Lao Triffin	Fairhaven Furniture	lao@fairhaven-furniture.com
Bill Neale	Radiall	bill.neale@radiall.com
Carlos Eyzaguirre	CNH	ceyzaguirre at newhavenct.gov
Kerry Triffin	~~TH Furniture (TH Building LLC)~~ TRIFFIN BUILDING LLC	
Susmita Sttola	City Plan Dept	Sattota@newhavenct.gov
Keryn M Gilvarg	City Plan	kgilvarg@newhavenct.gov